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TREE MEDICATION AS A CONTROL OF THE MOUNTAIN PINE BEETLE IN WESTERN WHITE PINE

1934 INVESTIGATIONS

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Respectfully submitted

W. D. Bedard

PREVIOUS INVESTIGATION

The first attempt to use tree medication as a control measure for the mountain pine beetle in western white pine was made in 1930. Prior to that time, however, considerable injection work had been done by other investigators against various bark beetles in different tree species. Studies were made by Patterson in California; Beal, St. George, and Caird[1] in North

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[1] St. George, R. A. and Caird, R. W. 1929. Report on tree medication studies conducted at Asheville, N. C. Unpublished report.

Carolina; and St. George, Gibson and Rust[2] in Montana.

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[2] St. George, R. A. and Gibson, A. L. 1931. Tree injection studies with lodgepole pine and notes on western white pine. Unpublished report.

No attempt will be made to review these earlier investigations, but a brief resume of the early white pine studies[3&4] will be included to give a complete picture of this work. The injections prior to the fall of 1933 showed:

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[3] Gibson, A. L. and Bedard, W. D. 1933. Tree medication as a control of the mountain pine beetle in western white pine. Unpublished report.

4/ Bedard, W. D. 1934. Additional information concerning tree medication as a control of the mountain pine beetle in western white pine. Unpublished report.

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1. Several methods of injection were attempted, but the saw kerf-tin collar method was found to be most successful.

2. That a high percent of the mountain pine beetle brood infesting a western white pine tree can be destroyed by injecting the tree with an aqueous solution of sodium arsenate.

3. Indications were that infested trees must be treated within 60 days after attack and that the minimum amount of poison necessary to kill the brood is 4 ounces of sodium arsenate dissolved in three quarts of water.

4. Although some parent adult beetles emerge from the medicated trees, the percent of those which attack again is not sufficient to constitute a drawback to this method of control.

On September 6, 1933, $3,000 of the Emergency Conservation Fund were made available to test the practicableness of tree medication as a control method by actually instituting a small control project. This experiment permitted the drawing of two main conclusions:

1. The man-day production of a medication treating crew is three times as great as under our present method of decking and burning the infested logs. Thus, this method is less costly than present mountain pine beetle control methods in western white pine.

2. The technique of injection is readily mastered by the ordinary unskilled laborers usually employed as treaters on insect-control projects, which shows the method is practical to apply.

EXAMINATION OF TREES TREATED DURING 1933

As it had been learned from earlier experiments that complete mortality in medicated White Pine trees does not occur until the spring following injection, the trees treated during the Experimental Medication Control Project were not tested until June, 1934. At this time 326 of the 433 medicated trees were felled and examined for brood mortality. Examinations were made by removing a quarter-square-foot sample of bark from all four sides of the tree at various heights along the stem. The first sample was taken below the point of injection, and the remaining samples were taken at 10-foot intervals above the point of injection until the height of infestation had been reached. In each of these samples the number of attacks, number of larval mines, and number of living mountain pine beetle larvae, pupae and adults were counted. As there is a normal mortality in mountain pine beetle broods of 90 percent from egg to emergence, it is difficult to determine what portion of the mortality occurred normally or what portion resulted from the poison, in those trees in which there was not a complete mortality. In an attempt to overcome this difficulty, three different methods of sampling were used. In the first method, the percent survival

was determined by dividing the number of living individuals found in the samples by the number of individuals in a normal brood. To secure the normal brood for the particular tree in question, the first step was to multiply the number of attacks in the samples by the average number of eggs per attack which gave the potential or total maximum brood which could have been in the samples. Then as the normal mortality is approximately 90 percent from egg to emergence, the potential brood was divided by 10 to secure the number of beetles in a normal brood or the number of D. monticolae which should be present in the samples. This method is based on averages, and this weakness was sometimes shown in those trees which had a complete mortality on three sides of the tree, yet the calculations would show a high percent of survival.

The second method simply recorded complete mortality where it had occurred and no mortality where any living brood was found. This obviously is incorrect in many cases because of the streaked distribution of the poison in the upper portion of some trees and also because one or two larvae were sometimes found where the remainder of the brood had been killed.

The third method used the number of larval mines found in the samples as representative of the normal brood produced. Thus, the number of living individuals divided by the number

of larval mines yielded the percent survival. Although better than the two preceding methods, the weakness of this method is that it does not take into consideration the normal mortality occurring in the larval stage. However, for want of something better all mortality percentages in the following tables have been determined by this method.

Experimental Trees

During the summer of 1933, prior to the E.C.W. project, 23 trees were medicated to secure more information concerning the length of time after attack during which a tree can be successfully medicated; to test new methods of injection, and various poisons. The data from these trees are arranged individually in Table I.

Table I

Trees treated by Various Methods and with Different Poisons

Tree number	D.B.H. in inches	Date attacked	Date Medicated	Elapsed time (days)	Method of treatment	Dosage	% mortality	% adult emergence holes per sq. ft.	Remarks
1/33	36"	7/18	8/1	14	7 1" holes with 2 tang. branches ea.	½lb.sod. ars.3 qt. H20	85%	9	Green tops
2/33	18"	7/18	8/1	14	2 1" holes w.2 tang. br.ea.	½lb.sod. ars.3 qt H20	100%	2	Green top
3/33	26"	7/18	8/1	14	1 hole in ea lateral root-6 roots	½lb.sod. ars.3 qt H20	90%	11	Green top
4/33	24"	7/15	8/9	25	Saw kerf tin collar	½lb.sod. fluosilicate 3qts H20	80%	9	Green top
5/33	20"	7/25	8/9	15	"	½lb.sod. ars.(bulk) 3qt.H20	100%	7	Green top
6/33	19"	7/24	8/8	15	"	½lb.sod. flouride 3qt.H20	100%	0	Green top
7/33	25	7/1	8/20	50	"	½lb.sod. ars.3 qt H20	100%	12	Heavy blue stain, fading top
8/33	13	7/20	8/8	19	"	½lb.bicloride mercury 3qt.H20	100%	4	Solution corrodes tin forming white precipitate in liquid & bl. deposit on tin.No corrosion when tin greased.

Table I (Cont'd)

Tree number	D.B.H. in inches	Date attacked	Date Medicated	Elapsed time (days)	Method of treatment	Dosage	% mortality	# adult emergence holes per sq ft	Remarks
9/33	25	7/10	8/8	29	Saw kerf tin collar	½lb.sod. flouride 3qts H20	75%	10	Green top
10/33	18	7/20	8/29	40	"	½lb.sod. ars.3 qts H20	100%	11	Green top
11/33	17	7/1	8/20	50	"	"	85%	9	Heavy blue stain. Beginning to fade.
12/33	24	7/20	8/20	50	"	"	100%	10	" " " "
13/33	24	7/24	8/23	30	"	"	100%	0	Partial blue stain - green foliage
14/33	21	7/24	8/23	30	"	"	100%	6	" " "
15/33	23	7/21	8/8	11	"	½lb.MgCl2 3qts H20	50%	10	Same as tree #8. Green top.
16/33	14	6/29	8/2	40	Rubber collar saw kerf	½lb.sod. ars.3qts H20	50%	9	Used ¼' tubing at first. This was too small. Medicated with large tubing. White fungus all way round on root collar. No grease. green top.
17/33	22	7/28	8/7	10	" " "	"	100%	0	2 leaks. No grease used. Faded top.
18/33	11	7/28	8/2	5	" " "	"	100%	3	Greased used. Few small leaks. Green top
19/33	24	7/28	8/7	10	" " "	"	100%	12	Badly convoluted. Grease used. No leaks. Green top.

Table I (Cont'd)

Tree number	D.B.H. in inches	Date attacked	Date Medicated	Elapsed time (days)	Method of treatment	Dosage	% mortality	# adult emergence holes per sq ft	Remarks
20/33	29	7/28	9/26	60	Tin collar saw kerf	½lb.sod. ars. 3 qts H2O	93%	11	Sorrell top
21/33	17	8/8	8/9	30	"	½lb.bulk sod.ars. 3qts H2O	95%	0	Green top
22/33	18	7/10	8/7	20	Rubber collar saw kerf	½lb.sod. ars.	100%	0	Very heavy pitch flow. Grease used.
23/33	21	7/18	9/26	30	Tin collar. Saw kerf	"	100%		Sorrell top.

An analysis of these data from the experimental trees shows the following: (1) Complete kill in trees treated with 1/4 pound sodium arsenate up to 40 days after attack, 95 percent kill in trees treated withthe same dosage from 41 to 50 days after attack, and 93 percent mortalitywith the same dosage in trees from 51 to 60 days after attack. (2) 92 percent mortality in trees injected by means of tangential auger holes with 1/4 lb sodium arsenate, and 90 percent kill in one tree which was injected through the roots by this method. (3) 80 percent kill using sodium fluosilicate. (4) 87 percent with sodium fluoride; (5) 97 percent using bulk sodium arsenate; and (6) 75 percent mortality by injecting the trees with mercuric chloride. A discussion of similar experiments on a more extensive scale which were made during the 1934 injections will be given later in this report. Thus, considerable additional data pertaining to this subject will be available when these trees are examined in the spring of 1935.

Control Project Trees

Two methods of injection described in the 1934 report[4] were used in medicating the trees during the ECW control project. Table II contains data from the trees injected by means of the saw kerf-rubber band method, which are arranged according to the time elapsing from attach to injection. Table III is the same arrangement of data from the trees injected by means of the saw

Kerf-tin collar method. It is to be noted in both these tables that the dates of attach are only approximate, because they could not be estimated accurately except within fifteen-day periods.

Table II

RUBBER COLLAR TREES ARRANGED ACCORDING TO TIME ELAPSING FROM ATTACK TO INJECTION

Tree No.	Approx date of attack	Date medicated	Elapsed time (days)	Phloem cond.	Percent Kill	Remarks
70	6/15 to 6/30	9/20	89	dead	95	Old tree, but dosage was effective to last sample where brood was abundant.
107	7/1 to 7/15	9/26	81	"	?	Cerambycid work too heavy to distinguish Dm. work.
98	7/1 to 7/15	9/26	80	"	40	Too old.
101	"	"	80	"	50	No apparent reason for lack of kill.
102	"	"	80	"	100	
108	"	"	80	"	70	Old tree.
110	"	"	80	"	25	" "
116	"	"	80	"	100	
156	"	"	80	"	97	
117	"	9/25	79	"	40	Probably too old.
122	"	"	79	"	30	" " "
129	"	"	79	"	40	" " "
82	"	9/20	74	"	100	
89	"	9/20	74	"	100	
69	"	"	73	"	100	Heavy Cerambycid work above 25'
104	7/8 to 7/22	9/25	72	"	90	
50	7/5 to 7/31	9/17	71	"	50	Probably too old
52	7/1 to 7/15	"	71	"	98	

Table II (Cont'd)

Tree No.	Approx. date of attack	Date medicated	Elapsed time (days)	Phloem cond.	Percent Kill	Remarks
74	7/8 to 7/22	9/19	66	dead	95	
154	7/15 to 7/31	9/26	65	"	80	
157	7/15 to 7/31	9/26	65	part dead	70	
159	"	"	65	dead	100	
180	"	"	65	"	30	
63	7/8 to 7/22	9/17	64	"	100	
100	7/15 to 7/31	9/25	64	"	50	
103	"	"	64	"	100	
105	"	"	64	"	80	
106	"	"	64	"	60	
111	"	"	64	"	100	
112	"	"	64	"	70	
119	"	"	64	"	70	
120	"	"	64	"	85	
128	"	"	64	"	80	
97	7/18 to 8/1	9/26	63	"	90	Few scattered larvae
155	"	"	63	"	70	
115	"	9/25	62	"	98	Few larvae at 45' complete kill to this point.
130	7/15 to 7/31	9/23	62	"	100	

Table II (Con't)

Tree No.	Approx. date of attack	Date medicated	Elapsed time (days)	Phloem cond.	Percent kill	Remarks
71	7/15 to 7/31	9/20	59	dead	30	Lodge pole. No reason for lack of kill. Bands hard to apply on lodgepole because of convolutions.
72	"	"	59	"	100	
83	"	9/19	58	"	100	
84	"	"	58	"	30	No reason
87	"	"	58	"	100	
88	"	"	58	"	100	
51	"	9/17	56	"	100	
57	"	"	56	"	80	
58	"	"	56	"	100	
95	7/25 to 8/8	9/26	56	"	100	
152	"	"	56	Partly dead	80	No reason
178	"	"	56	Flown dead	80	Killed to 35' brood at 45' and 55'
113	"	9/25	55	"	70	Small tree, very few larvae.
118	"	"	55	"	60	No reason
123	"	"	55	"	80	
91	7/22 to 8/5	9/19		Partly dead	100	
85	7/25 to 8/9	9/20		dead	?	Too much acanthocinus work to distinguish kill.
124	8/5 to 8/19	9/2		green	50	No apparent reason.
	8/1 to	9/		dead	100	

Table II (Cont'd)

Tree No.	Approx. date of attack	Date mediated	Elapsed time (days)	Phloem cond.	Percent kill	Remarks
90	8/1 to 8/15	9/19	42	green	50	Kill to 25'. Small streak from 25' to 45'.
131	8/9 to 8/23	9/23	38	dead	90	
138	8/15 to 8/31	9/26	34	green	90	
140	"	"	34	"	100	
126	"	9/25	33	"	90	
127	"	"	33	"	80	
48	"	9/17	25	"	100	
49	"	"	25	"	95	No apparent reason
125	8/25 to 9/8	9/25	24	"	100	
166	9/1 to 9/15	9/26	19	"	100	
135	"	"	18	"	50	No apparent reason
136	"	"	18	"	100	
137	"	"	18	"	100	
86	9/1 to 9/15	9/20	13	"	100	
55	"	9/17	9	"	80	Collar leaked badly.

Table III

Tim Collar Trees Arranged According to Time Elapsing From Attack to Injection

Tree No.	Approx. date attacked	Date Medicated	Elapsed time (days)	Phloem cond.	Percent kill	Remarks
307	6/15 to 6/30	10/3	102	dead	10	Too old.
14B	"	10/1	100	"	100	Brood killed out by cerambycids above 25'.
8-6	"	9/30	98	"	60	Too old. Brood killed to 50'.
199	"	9/29	96	"	100	
7-C	"	"	95	"	60	Brood killed to 45'.
16-C	"	"	"	"	75	" " " 20'.
51-C	"	9/27	94	"	80	Too old.
312	7/1 to 7/15	10/3	88	"	10	" ".
308	"	"	"	"	50	" ".
313	"	"	"	"	0	" ".
222	"	9/29	83	"	70	Brood killed in lower 1/2 of tree.
145	"	9/28	82	"	98	2 larvae at 35'.
181	"	"	"	"	90	Scattered brood.
254	7/3 to 7/18	10/1	82	"	10	Too old.
164	7/1 to 7/15	9/27	81	"	92	Killed to 45'. Light brood to 73'.
161	"	"	81	"	80	Too old.
176	"	"	"	"	100	
189	"	"	"	"	70	
200	"	"	"	"	100	Cerambycids above 45'.

Table III (Cont'd)

Tree No.	Approx. date attacked	date Medi-dated	Elapsed time (days)	Phloem cond.	Percent kill	Remarks
207	7/1 to 7/15	9/27	81	dead	90	
305	7/15 to 7/31	10/3	81	"	99	4 larvae at 45'. Otherwise complete kill to 75'.
44-C	7/1 to 7/15	9/27	80	partly dead	99	3 larvae at 25'.
53C	"	"	80	Dead	95	Complete kill to 50'. Very light brood from 50' to 70'.
1	7/8 to 7/22	10/3	80	"	100	
141	7/1 to 7/15	9/28	80	"	100	
129	"	9/20	75	"	100	
32	"	9/21	75	"	98	Too old.
33	"	"	75	"	60	" " .
241	7/15 to 7/31	10/1	75	"	50	Kill 1/2 way up tree.
243	"	"	"	"	40	Scattered brood.
245	"	"	"	"	80	Kill to 15'. Very light brood to 35'.
9/C	7/8 to 7/22	9/20	73	Partly dead	100	
67	7/1 to 7/15	9/19	73	Dead	90	
248	7/18 to 8/1	10/1	73	"	100	
37	7/15 to 7/31	10/3	72	"	60	Probably too heavily blue stained.

Table III (Cont'd)

Tree No.	Approx. date attached	Date medicated	Elapsed time (days)	Phloem cond.	Percent kill	Remarks
38	7/15 to 7/31	10/3	72	dead	100	Heavy cerambycid and Ips work above 25'.
40	"	"	"	"	100	Lodgepole
309	"	"	"	"	99	1 larva at 25'.
310	"	"	"	"	55	Scattered larvae throughout.
317	"	"	"	"	70	" " "
120	7/1 to 7/15	9/29	71	"	0	Badly convoluted. Poor saw kerf which did not to into convolutions.
2	7/15 to 7/31	10/2	71	"	100	
50	7/1 to 7/15	9/17	71	"	50	Too old.
65	7/15 to 7/31	10/2	71	"	100	
267	7/14 to 7/30	9/30	70	"	100	
287	7/15 to 7/31	10/1	70	"	90	
262	"	9/30	69	"	100	
263	"	"	69	Small part still green	100	
277	"	"	69	dead	100	
12B	7/18 to 8/2	10/1	68	"	100	Complete kill at April exam. South exposure.
13B	"	"	68	"	100	"
190	7/15 to 7/31	9/29	68	"	90	

Table III (Cont'd)

Tree No.	Approx. date attacked	Date medi-dated	Elapsed time (days)	Phloem cond.	Percent kill	Remarks
191	7/15 to 7/31	9/29	68	dead	100	
198	"	"	"	"	"	Lodgepole
201	"	"	"	"	"	Cerambycids above 25'
210	"	"	"	"	98	2 larvae at 25'.
220	"	"	68	"	100	
221	"	"	68	"	100	Lodgepole.
225	"	"	"	"	99	1 larva at 5'.
228	"	"	"	"	100	
237	7/18 to 8/2	10/1	"	"	40	Kill at 5'. Light brood at 15' & 25'. Heavy brood at 35'.
238	"	10/1	"	"	100	
244	"	"	"	"	"	
251	"	"	"	"	"	
Extra	"	"	"	"	"	
256	7/15 to 7/31	9/30	"	"	"	
10-C	"	9/28	67	"	"	Lodgepole.
72-C	"	"	"	"	"	
80-C	"	"	"	"	80	
142	"	"	"	"	100	Heavy cerambycid work above 35'.
143	"	"	"	"	98	1 larva at 35'.

Table III (Cont'd)

Tree No.	Approx date attacked	Date Medicated	Elapsed time (days)	Phloem cond.	Percent kill	Remarks
148	7/15 to 7/31	9/28	67	dead	100	
149	"	"	"	"	"	
150	"	"	"	"	"	
151	"	"	"	"	"	Lodgepole
264	7/18 to 8/2	9/30	"	"	"	
23-C	7/15 to 7/31	9/27	66	"	50	?
242	7/18 to 8/1	9/30	66	"	100	
247	"	"	66	"	100	Small tree.
20-C	7/15 to 7/31	9/27	65	partly dead	100	
46-C	"	"	"	Dead	100	
47-C	"	"	"	"	95	
48-C	"	"	"	"	80	Kill up to 50'.
55-C	"	"	"	"	98	
57-C	"	"	"	"	88	Kill to 15'. Very light scattered brood above this point.
147	7/18 to 8/1	9/28	"	partly dead	100	
158	7/15 to 7/31	9/27	"	Dead	100	
163	"	"	"	"	"	

Table III (Cont'd)

Tree No.	Approx. date attacked	Date Medicated	Elapsed time (days)	Phloem cond.	Percent kill	Remarks
17-C	7/15 to 7/31	9/28	64	partly dead	95	Few larvae at 35' examination.
54	7/8 to 7/22	9/17	"	Dead	95	
162	7/19 to 8/2	9/27	63	Partly dead	70	No reason.
22	7/8 to 7/22	9/16	62	Dead	90	Complete kill in all but last sample at 55'.
205	7/22 to 8/5	9/29	61	Partly green	100	Lodgepole.
31	7/15 to 7/31	9/21	60	Dead	100	
226	7/25 to 8/8	9/29	59	"	100	
281	7/25 to 8/9	9/30	59	"	99	1 larva at 35'
202	7/25 to 8/8	9/28	58	"	100	
144	"	"	58	"	98	2 larvae at 15'. Cerambycid work above 45'.
67-C	"	9/27	57	Partly dead	100	
3	8/1 to 8/15	10/3	56	Dead	100	
30	7/20 to 8/3	9/21	56	Partly dead	100	
39	8/1 to 8/15	10/3	56	Dead	100	Heavy cerambycid & Ips work above 35'.
56	7/15 to 7/31	9/17	56	"	100	

Table III (Cont'd)

Tree No.	Approx. date attacked	Date Medi-dated	Elapsed time (days)	Phloem cond.	Percent kill	Remarks
58	7/15 to 7/31	9/17	56	dead	95	No reason
62	"	"	56	"	100	
20	"	9/16	55	"	70	Kill to 45'. No reason for lack of kill above this point.
21	"	"	55	"	100	
22	7/8 to 7/22	9/16	55	"	90	
23	7/15 to 7/31	"	"	"	80	Kill in all but last sample.
24	"	"	"	"	100	
25	"	"	"	"	50	No reason.
233	8/1 to 8/15	10/1	"	"	10	No brood at 5'. One larva at 15'. Heavy brood above this point.
234	"	"	"	"	0	No reason.
15	7/15 to 7/31	9/15	54	"	80	" "
16	"	"	"	"	95	" "
265	8/1 to 8/15	9/30	54	Partly dead	70	" "
35	7/22 to 8/6	9/21	53	partly green	100	
6-C	8/1 to 8/15	9/29	52	Dead	100	
21-C	"	"	51	Partly dead	100	
83-C	"	"	"	"	50	Streaked kill.

Table III (Cont'd)

Tree No.	Approx. date attacked	Date Medicated	Elapsed time (days)	Phloem cond	Percent kill	Remarks
192	8/1 to 8/15	9/29	51	Partly green	100	
193	"	"	"	"	100	Lodgepole
194	"	"	"	"	100	"
45-C	"	9/28	50	Green	75	No reason
50-C	"	"	"	Partly dead	90	Kill to 40'
56-C	"	"	"	Dead	80	Kill to 35'
54-C	"	"	"	Partly dead	50	No reason. Kill at 5' & 25' but no kill at 15'.
74-C	"	"	"	Dead	56	Kill to 15'.
75-C	"	"	"	"	44	No reason.
76-C	"	"	"	"	100	
81-C	"	"	"	Partly dead.	50	No reason.
169	"	"	"	"	80	Kill to 35'.
170	"	"	"	"	94	
172	"	"	"	Green	95	
306	"	10/3	"	Dead	90	
316	8/8 to 8/22	"	49	"	100	
46	"	"	48	Partly dead	100	
11-C	8/1 to 8/15	9/29	47	Green	100	

Table III (Cont'd)

Tree No.	Approx. date attacked	Date Medicated	Elapsed time (days)	Phloem cond.	Percent kill	Remarks
18-C	8/1 to 8/31	9/29	45	Green	36	Kill to 10'
49-C	8/8 to 8/22	9/27	"	"	100	
52-C	"	"	"	"	"	
14-C	8/8 to 8/22	9/29	44	"	98	Kill to 35'.
22-C	"	"	"	Partly dead	100	
82-C	"	9/28	"	Green	100	
34	8/1 to 8/15	9/21	"	"	100	
42	8/15 to 8/31	10/3	41	Partly green	100	
44	"	"	"	"	100	
45	"	"	"	"	100	
60	8/1 to 8/15	9/17	"	"	100	
177	8/10 to 8/24	9/27	"	"	100	
311	8/15 to 8/31	10/3	"	Dead	99	3 larvae at 55'.
315	"	"	"	"	100	
319	"	"	"	"	83	
5-C	8/10 to 8/25	9/27	39	Partly dead	100	
12	8/1 to 8/15	9/15	38	"	60	Kill to 15'
13	"	"	"	"	95	" " "

Table III (Cont'd)

Tree No.	Approx. date attacked	Date medicated	Elapsed time (days)	Phloem cond.	Percent kill	Remarks
231	8/15 to 8/31	10/1	38	dead	90	6 larvae at 35'
235	"	"	38	"	100	
239	"	"	"	"	90	
240	"	"	"	"	100	
247	"	"	"	"	80	
249	"	"	"	"	100	
250	"	"	"	"	100	
253	"	"	"	Partly dead	100	
258	"	9/30	"	Green	80	Kill to 25'
259	"	"	"	Partly green	100	
261	"	"	"	Green	100	
266	"	"	"	"	100	
271	"	"	"	Dead	100	
274	"	"	"	Green	100	
276	"	"	"	"	100	
279	"	"	"	Partly	50	No reason
284	"	"	"	Dead	98	8 larvae at 45'.
286	"	"	"	Partly green	95	
28	8/8 to 8/22	9/21	37	Green	75	No apparent reason.
195	8/15 to 8/31	9/29	37	"	100	

Table III (Cont'd)

Tree No.	Approx. date attacked	Date medicated	Elapsed time (days)	Phloem cond.	Percent kill	Remarks
196	8/15 to 8/31	9/29	37	Green	99	Cerambycids above 45'
203	"	"	"	Partly green	80	No reason
206	"	"	"	Green	99	1 larva at 15'.
217	"	"	"	Partly green	85	10 larvae at 5' & 1 at 25'. Remainder of brood killed up to 65'.
218	"	"	"	"	100	
223	"	"	"	Green	100	
227	"	"	"	"	100	
15-C	"	"	36	"	50	Kill up to 25'.
71-C	"	9/28	"	"	87	
77-C	"	"	"	"	65	
1-C	"	"	35	"	100	
185	"	9/27	"	Partly green	99	1 larva at 15'.
216	8/18 to 9/1	9/29	"	Green	95	1 larva at 15' & 2 at 35'.
257	8/19 to 9/2	9/30	"	"	100	
314	8/25 to 9/8	10/3	32	Partly green	40	No reason
17	8/8 to 8/22	9/15	31	Green	100	
58-C	8/20 to 9/5	9/27	30	"	100	
73-C	8/22 to 9/5	9/28	"	"	100	

Table III (Cont'd)

Tree No.	Approx. date attacked	Date medi-cated	Elapsed time (days)	Phloem cond.	Percent kill	Remarks
70-C	8/23 to 9/6	9/28	29	green	100	
260	8/25 to 9/9	9/30	28	Green	100	
268	"	"	"	"	100	
19-C	8/25 to 9/10	9/29	27	"	33	No reason
79-C	8/25 to 9/8	9/28	"	"	100	
36	7/20 to 8/3	9/21	26	Dead	100	Spruce
41	9/1 to 9/15	10/3	25	Green	100	Lodgepole
19	8/15 to 8/31	9/16	24	"	50	
285	9/1 to 9/15	10/1	24	"	70	No reason
280	"	9/30	23	"	90	6 larvae at 35'
275	"	"	23	"	100	
18	8/15 to 8/31	9/15	23	"	100	
14	"	"	23	"	95	No reason
208	9/1 to 9/15	9/29	22	"	95	2 larvae at 15' & 1 at 35'
209	"	"	"	"	100	
224	"	"	"	"	"	
246	"	"	"	"	"	

Table III (Cont'd)

Tree No.	Approx. date attacked	Date medi-cated	Elapsed time (days)	Phloem cond.	Percent kill	Remarks
252	9/1 to 9/15	9/29	22	Green	100	
65-C	"	9/28	21	"	"	
187	"	9/29	"	"	80	Ips above 55'.
191	"	"	"	"	95	
197	"	"	"	"	50	
204	"	"	"	"	100	
3-C	"	9/27	20	"	100	
24-C	"	"	"	"	100	
25-C	"	"	"	"	100	
62-C	"	"	"	"	100	
64-C	"	"	"	"	100	
69-C	"	"	"	"	75	Collar leaked badly
165	"	"	"	"	40	No reason.
171	"	"	"	"	80	" "
173	"	"	"	"	100	
174	"	"	"	"	70	Collar leaked.
175	"	"	"	"	100	
182	"	"	"	"	95	
183	"	"	"	"	100	
184	"	"	"	"	100	
66-C	"	9/26	19	"	100	
11	8/22 to 9/6	9/15	16	"	90	Kill to 65' except for heavy brood at 55'

Table III (Cont'd)

Tree No.	Approx. date attacked	Date medicated	Elapsed time (days)	Phloem cond.	Percent kill	Remarks
68	9/1 to 9/15	9/19	12	Green	90	No reason

Age of Attack vs Mortality

In examining these two tables it will be seen that a somewhat higher mortality was secured in those trees treated before the attacks were 60 days old, although a surprisingly heavy kill occurred in the olderattacks. The rubber-band group shows a mortality of 86.1 percent in injections made before theattacks were 60 days old as compared with 75.2 percent in the older attacks. In the tin-collar group thedifference is not so marked, being 85.4 percent for the older trees and only 87.5 percent for those attacks treated before 60 days. However, by making the computation on the basis of 70 days, the spread is much greater, showing a mortality of 89.4 percent in the attacks under 70 days, andonly 75.6 percent in trees which were treated when the attacks were more than 70 days old.

In Table IV the trees are divided further into 30-day groupings according to the age of the attack.

Table IV.

MORTALITY RESULTING FROM MEDICATION OF VARIOUS-AGED ATTACKS

Age of attack in days	Rubber Band: Number of trees examined	Rubber Band: Percent mortality	Tin collar: Number of trees examined	Tin collar: Percent mortality
1-30	9	91.6	42	86.3
31-60	24	81.6	99	88.0
61-90	36	76.5	86	86.7
91-120			7	69.2
Average mortality		80.3		86.7

From the preceding tables and discussions it can readily be seen that the age of the attack at the time of medication is one of the most important factors governing the success or failure of the injection. In the older attacks where blue-stain development has progressed for some time, the conduction of the poison solution is undoubtedly impaired. This fact was evident in all trees in which complete kill had not occurred. In these trees all the broods were destroyed up to a certain point, and from thence upward the kill would be patchy, streaked, or absent entirely.

Tree Diameter vs. Mortality

As all trees were treated with a minimum dose of sodium arsenate, it is possible that the larger-diameter trees would show less mortality than the trees of small size. In tables V and VI the trees are arranged according to diameters. Trees injected by the rubber-band method are in Table V, and those medicated by means of the tin collar are in Table VI.

Table V.
Rubber Collar Trees Arranged According to Diameters

Tree No.	dbh in ins.	Approx. date attacked	Date medicated	Elapsed time (days)	Phloem cond.	Percent kill	Remarks
59	28	7/15 to 7/31	9/17	56	dead	100	
84	24	"	9/20	58	"	30	Too old.
86	24	9/1 to 9/15	"	13	Green	100	
63	20	7/8 to 7/22	9/17	64	Dead	100	Heavy Cerambycid work above 15 '.
50	18	7/1 to 7/15	"	71	"	50	Probably too old.
70	18	6/15 to 6/30	9/20	89	"	95	Old tree but dosage was effective to last sample where broods abundant.
55	16	9/1 to 9/15	9/17	9	Green	80	Collar leaked badly
74	16	7/8 to 7/22	9/19	66	Dead	95	
48	14	8/15 to 8/31	9/17	25	Green	100	
85	14	7/25 to 8/9	9/20	49	Dead	?	Too much Acanthocinus work to distinguish kill
57	14	7/15 to 7/31	9/17	56	"	80	Showed few scattered larvae all way up.
87	14	"	9/20	58	"	100	
53	13	7/1 to 7/15	9/17	71	"	90	Probably too old.
51	12	7/15 to 7/31	"	56	"	100	
69	12	7/1 to 7/15	9/19	73	"	100	Very heavy cer. work above 25'

Table V. (Cont'd)

Tree No.	dbh in ins.	Approx. date attacked	Date medicated	Elapsed time (days)	Phloem cond.	Percent kill	Remarks
71	12	7/15 to 7/31	9/20	59	Dead	100	
72	12	"	"	"	"	30	
49	10	8/15 to 8/31	9/17	25	Green	95	Probably too old.
73	10	8/1 to 8/15	9/20	43	Dead	100	
83	10	7/15 to 7/31	9/20	58	"	"	
88	10	"	"	"	"	"	
82	5	7/1 to 7/15	"	74	"	"	

Table VI.

Tin Collar Trees Arranged According to Diameters.

Tree No.	dbh: in ins:	Approx date of attack	Date medi-cated	elapsed time (days)	Phloem cond.	Per cent kill	Remarks
1	30	7/8 to 7/22	10/3	80	Dead	100	
13	30	8/1 to 8/15	9/15	38	Partly	95	Kill to 15'. Very few larvae at 25' & 35'.
18	30	8/15 to 8/31	"	23	Green	100	
26	30	7/15 to 7/31	9/16	55	Dead	98	
38	30	"	10/3	72	"	100	Heavy cerembycid & Ips work above 25'.
17	26	8/8 to 8/22	9/15	31	Green	100	
34	26	8/1 to 8/15	9/21	44	"	100	Very small trees.
14B	24	6/15 to 6/30	10/1	100	Dead	100	Brood killed by Cerambycids above 25'.
12	24	8/1 to 8/15	9/15	38	Partly dead	60	Kill to 15'.
14	24	8/15 to 8/31	"	25	Green	95	No reason.
16	24	7/15 to 7/31	"	54	Dead	95	Probably too old.
19	24	8/15 to 8/31	9/16	24	Green	50	Many very small dead pupae. This is apparent in some trees that growth seems to be stunted.
20	24	7/15 to 7/31	"	55	Dead	70	Kill to 45'. Heavy brood at 55' & 65'.
32	24	7/1 7/15	9/21	75	"	98	

Table VI (Cont'd)

Tree No.	dbh in ins.	Approx. date of attack	Date medicated	Elapsed time (days)	Phloem condition	Per cent kill	Remarks
37	24	7/15 to 7/31	10/3	72	Dead	60	Probably too heavily blue stained.
39	24	8/1 to 8/15	"	56	"	100	Heavy cerambycids & Ips work above 35'
44	24	8/15 to 8/31	"	41	Partly dead	100	Lodgepole
29	23	7/1 to 7/15	9/21	75	Dead	100	
14C	22	8/8 to 8/22	9/29	44	Green	98	Complete kill to 35'. Very light brood in last 10'. Infested to 50'
12B	20	7/15 to 7/31	10/1	68	Dead	100	Complete kill at April examination. South exposure.
12C	20	7/1 to 7/15	9/29	71	"	0	Badly convoluted. Saw kerf did not go into convolutions.
21	20	7/15 to 7/31	9/16	55	"	100	
25	20	"	"	55	"	98	
27	20	6/15 to 6/30	"	85	"	100	
?	20					100	
68	20	9/1 9/15	9/19	12	Green	90	No reason.
11C	18	8/1 to 8/15	9/29	47	"	100	
24	18	7/15 to 7/31	9/16	55	Dead	100	
33	18	7/1 to 7/15	9/21	75	"	60	
40	18	7/15 to 7/31	10/3	72	"	100	Lodgepole

Table VI (Cont'd)

Tree No.	dbh in ins.	Approx. date of attack	Date medicated	elapsed time (days)	Phloem cond.	Per cent kill	Remarks
46	18	8/8 to 8/22	10/3	48	Dead	100	
67	18	7/1 to 7/15	9/19	73	Dead	90	
18C	16	8/1 to 8/31	9/29	45	Green	36	Kill to 10'. Light brood above.
22C	16	8/8 to 8/22	"	51	Partly dead	100	
11	16	8/22 to 9/6	9/15	16	Green	90	Complete kill to 65' except for 5'. Heavy brood at 55'.
15	16	7/15 to 7/31	"	54	Dead	80	Probably too old.
35	16	7/22 to 8/6	9/21	53	Partly green	100	Very small trees
36	16	7/20 to 8/3	"	26	Dead	100	Spruce
62	16	7/15 to 7/31	9/17	56	"	100	
65	16	"	10/3	71	"	100	
15C	14	8/15 to 8/31	9/29	36	Green	50	Kill to 20'
2	14	7/15 to 7/31	10/3	71	Dead	100	
22	14	7/8 to 7/22	9/16	62	"	80	Kill in all bur last two samples.
?	14					70	
56	14	7/15 7/31	9/17	56	"	100	
60	14	8/1 to 8/15	"	41	"	100	

Table VI. (Cont'd)

Tree No.	dbh in ins.	Approx. date of attack	Date mediated	Elapsed time (days)	Phloem condition	Per cent kill	Remarks
13B	12	7/15 to 7/31	10/1	68	Dead	100	Complete Kill at April examination. South exposure.
13C	12	8/1 to 8/15	9/29	51	Green	100	
3	12	"	10/3	56	Dead	100	
28	12	8/8 to 8/22	9/21	37	Green	75	No apparent reason.
45	12	8/15 to 8/31	10/3	41	Partly dead	100	
3C	10	9/1 to 9/15	9/27	20	Green	100	
5C	10	8/10 to 8/25	"	39	Partly dead	100	
6C	10	8/1 to 8/15	9/29	62	Dead	100	
7C	10	6/15 to 6/30	"	95	"	60	No apparent reason. Brood killed to 45'.
8C	10	"	9/30	98	"	60	No apparent reason. Brood killed to 50'.
9C	10	7/8 to 7/22	9/29	73	Partly dead	100	
19C	10	8/25 to 9/10	"	27	Green	33	No apparent reason.
20C	10	7/15 to 7/31	"	65	Partly dead	100	
21C	10	8/1 to 8/15	"	51	"	100	
41	10	9/1 to 9/15	10/3	25	Green	100	Lodgepole.

Table VI. (Cont'd)

Tree No.	dbh in ins.	Approx. date of attack	Date medicated	elapsed time (days)	Phloem cond.	Per cent kill	Remarks
42	10	8/15 to 8/31	10/3	41	Partly green	100	Lodgepole.
10	8	"	9/28	35	Green	100	
100	8	7/15 to 7/31	9/29	67	"	100	Lodgepole.
160	8	6/15 to 6/30	"	95	Dead	75	Kill to 20'.
170	8	7/15 to 7/31	"	64	Partly dead	95	Few larvae at 35'.
30	8	7/20 to 8/3	9/21	56	"	100	
54	8	7/8 to 7/22	9/17	64	Dead	95	
23	6	7/15 7/31	9/16	55	"	80	Kill in all but last two samples
52	6	7/1 to 7/15	9/17	71	"	98	
31	4	7/15 to 7/31	9/21	60	"	100	

In Tables V & VI only a small portion of the total number of trees treated is represented, because these are the only trees for which diameters are available. An analysis of Table V does show a decided correlation between diameter and mortality. Five trees from 4 to 10 inches d.b.h., showed 99.0 percent mortality, 13 trees from 11 to 20 inches, 86.1 percent mortality, and 3 trees from 21 to 30 inches 76.6 percent. However, Table VI shows no correlation whatever. In this group of trees 89.8 percent mortality was secured in 20 trees from 4 to 10 inches d.b.h., 88.0 percent in 32 trees from 11 to 20 inches, and 90.4 in 19 trees from 21 to 30. Similarly, when these two groups are averaged together, the 4-10 group shows 91.6 percent mortality, the 11-20 group 87.5 percent, and the 21-30 group 88.5 percent.

From these data it is apparent that tree diameter does not effect the mortality secured when western white pine trees infested with the mountain pine beetle are medicated with 4 ounces of sodium arsenate dissolved in 3 quarts of water.

THE 1934 MEDICATION CONTROL PROJECT

The success of the 1933 work lead to the institution of another similar project during 1934. As the results of the 1933 work indicated that the project had been started too late in the season, the 1934 experiment was begun approximately one month earlier, on August 20th, and was completed on September 18th. An organization comprising one 5-man spotting crew and

and 2-man treating crew was able to complete the work in the specified time. The men were quartered in the Honeysuckle bunkhouse on the Coeur d'Alene National Forest, and were boarded at the Forest Service mess. This arrangement had many advantages: It eliminated the necessity of setting up camp, hiring a cook, purchasing supplies, and from this point we were within easy traveling distance of Deception and Cascade Creeks, where the medication work was done.

Methods and Dosages

Whereas the 1933 project aimed more to test the economic possibilities of tree medication, the 1934 work had as its main objectives, (1) to test various chemicals not only for their toxicity against the bark beetles, but for their ability as wood preservatives to protect the trees from wood-destroying insects and decay, and (2) to secure more information concerning the effect of various physiological and environmental factors upon the amount of mortality secured by medication.

Practically all of the trees were injected by means of the saw kerf-tin collar method and when poisons such as mercuric chloride, zinc chloride, and copper sulphate were used, the tin collar was greased to prevent a chemical reaction which deposited mercury, zinc or copper on the tin. A series of 25 trees were medicated by boring a one-inch hole to the center of each large lateral root. Each hole was fitted with a cork, and a series of copper and rubber tubes brought the solution from a poison

can to the various corks. Both the tin collar and root-injection methods were used to medicate windthrown trees. The only variation necessary to apply these to the windfalls was in the tin-collar method, in which both edges of the tin, instead of only one, were nailed to the tree.

The various dosages and methods were spread throughout the duration of the project, so that the factor of climate would be constant. The distribution by age of attack was also watched carefully, so that each dosage and method of injection was represented proportionately in each of the various-aged attacks. In addition, the following data were secured for each of the white pine trees treated: diameter, foliage condition, date of attack, date of injection, hour of day at which injection was made, method of injection, dosage, attacks per square foot, percent and intensity of blue stain, insolation and temperature at time of injection, exposure, and remarks were added according to any additional facts which appeared pertinent, such as mechanical injury to the tree, dry sides, etc.

A total of 202 trees were treated as follows:

Table VII.

SUMMARY OF 1934 INJECTIONS

Poison	Dosage and Method [b]	No. trees inj.	Distribution according to age of attack in days							
			1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90
Mercuric Chloride	½ oz. by TC	15	3	3	2	2	2	1	1	1	
	2 " " "	15	2	2	2	2	1	2	2	2	
	5 " " "	15	3	4	2	2	1	1	1	1	
	10 " " "	15	3	3	2	2	1	2	1	1	
Sodium arsenate	4 " " "	20	3	3	2	3	2	2	2	3	
	10 " " "	20	2	3	2	2	3	3	2	2	1
	5 " " RI	25	4	5	4	3	3	2	2	2	
	5 " "RIW	9		1	1	2	2	1	1	1	
	5 " "TBW	9			1	2	1	1	2	1	1
Zinc chloride	8 " " TC	6	1	1	1	1	1	1			
	32 " " "	7	1	1	1	1	1	1	1		
Copper sulphate	4 " " "	6	1	1	1	1	1		1		
	8 " " "	6	1	1	1	1	1		1		
	16 " " "	6	1	1	1	1	1		1		
Sodium flouride	4 " " "	12	2	1	2	2	1	2	1	1	

[a] - Each dosage was dissolved in 3 quarts of water.

[b] - TC - Tin collar; RI - Root injection; RIW - Root injection in windfalls; TBW - tin band on windfalls.

It will be noted in Table VII that it was impossible to represent the windfalls in the lower-aged attacks owing to the early attach of the windfalls by the beetles. At the time of medication no freshly attacked windfalls were available.

In addition to the trees in Table VII, 4 green larch, 4 green Douglas fir, 4 green Engelmann spruce, and 4 green white fir were treated by the saw kerf-tin collar method with 3 ounces of mercuric chloride dissolved in 3 quarts of water. These trees were treated in order to determine whether this chemical will preserve log-cabin and rustic timber from insect attack.

COST OF PROJECT

The expenditures for the examination of the 1933 trees as well as the cost of locating an area for the 1934 experiments will be included in this section in order that the expenditures will be complete. However, the cost of the 1934 project will be shown separately for the purpose of comparison with other projects.

Table VIII
COST OF EXAMINING 1933 TREES

	Total expenditure	Cost per tree
Transportation	$ 27.68	$ .084
Subsistence	107.77	.331
Labor	223.84	.687
Total	$359.29	$1.102

Table IX
COST OF LOCATING 1934 AREA

	Total expenditure
Transportation and subsistence	$ 70.19
Labor	85.00
Total	$155.19

Table X

ITEMIZED COST OF 1934 PROJECT

		Total	Per tree	Total	Per tree
Labor	Spotting	$426.60	$2.112		
	Treating	208.74	1.033		
				$635.34	$3.145
Subsistence				168.30	.833
Transportation				10.87	.054
Equipment				3.04	.015
Materials				85.74	.424
Total				$903.29	$4.471

Comparison of 1933 and 1934 Projects

All items for the 1934 project showed a lower cost per tree than in 1933, except labor. The labor cost showed an increase of $0.914 per tree which resulted in a total increase of $0.143 per tree. Spotting costs were $0.754 higher and treating only $0.16 higher. The higher cost of spotting was due entirely to the large area it was necessary to cover in order to spot the required number of trees. This scattered infestation was of course reflected in the somewhat higher treating costs.

On a production basis the treating crew secured 4.12 trees per treating man-day as compared with 6.26 trees in the 1933 project. Even so, this production is very satisfactory, because only half as many trees were found on an area slightly larger than the one treated in 1933.

SUMMARY

1. - Prior to the fall of 1933, the experimental work with tree

medication in western white pine showed: (1) that a high percent of the mountain pine beetle brood infesting a western white pine tree can be destroyed by injecting the tree with an aqueous solution of sodium arsenate, (2) that the saw kerf-tin collar method is the most successful method of injection, (3) that the trees should be treated within 60 days after attack, (4) that the minimum amount of poison necessary to kill 100 per cent of the brood is 4 ounces of sodium arsenate dissolved in 3 quarts of water, (5) that the emergency of parent adult beetles from the medicated trees does not constitute a drawback to this method of control.

2. - An experimental control project during the fall of 1933 showed: (1) that the man-day production of a treating crew is three times as great as under our present method of decking and burning the infested logs, (2) that the technique of injection is readily mastered by the ordinary unskilled labor usually employed as treaters on insect-control projects.

3. - Examination of trees treated during this experimental control project indicated that the deterioration or blocking of the conducting tissue of the tree after attack is the most important factor affecting the amount of mortality secured by tree medication. Trees medicated from 1 to 30 days after attack showed 87.2 percent mortality; those treated from 31 to 60 days, 86.7 percent mortality; trees 61 to 90 after attack, 83.6 percent; and those injected 91 to 120 days after attach showed only 69.2 percent kill.

4. - Another similar project was instituted during 1934 to test various chemicals not only for their toxicity against bark beetles, but also for their ability as wood preservatives to protect the trees from wood-destroying insects and decay.

5. - The treating man-day production for the 1934 project, although less than that attained during 1933, was twice as great as the average number of trees treated per man-day by our present methods.